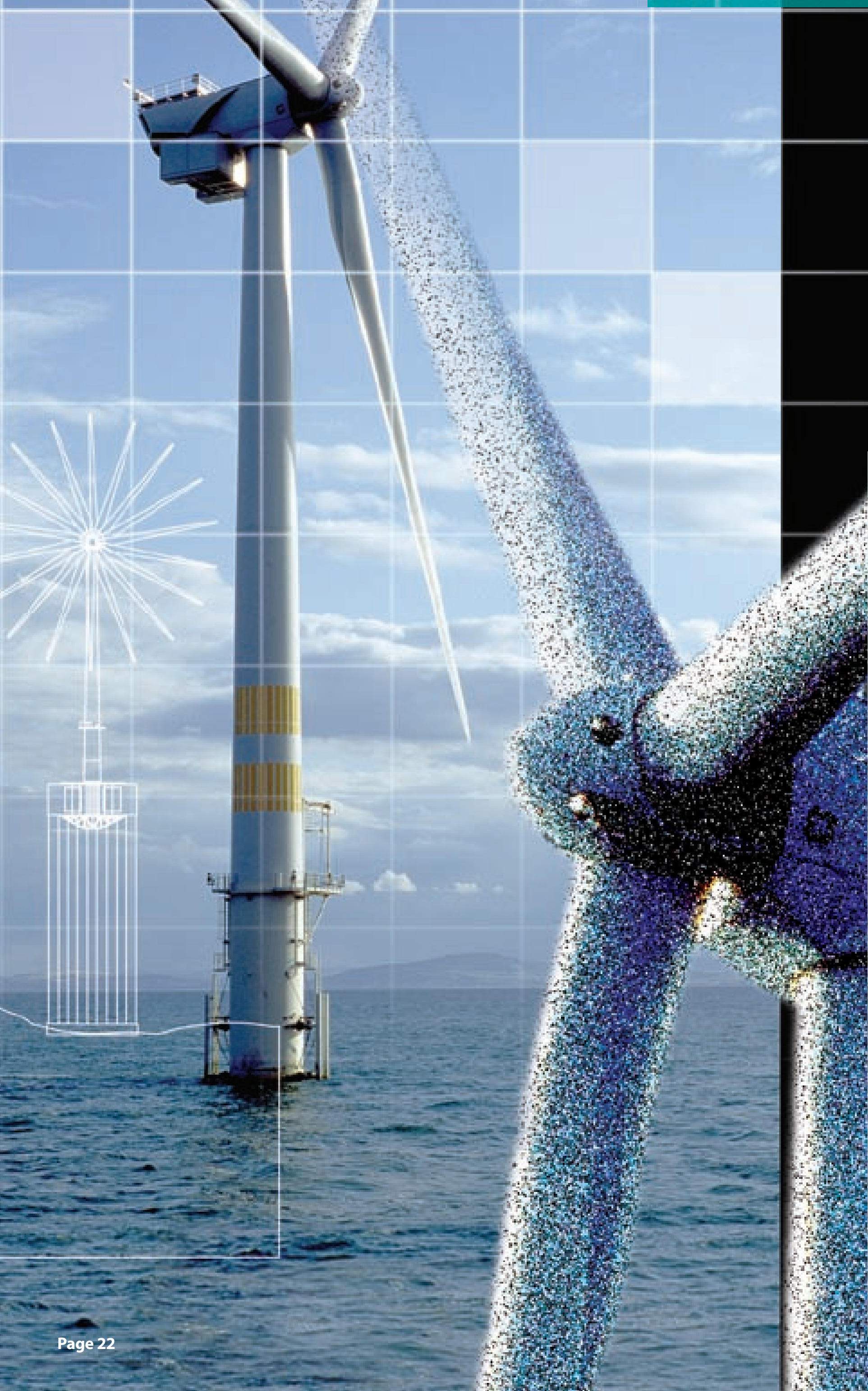
Harvesting the Ocean Wind

Generating Electricity with Deep-Water Wind Turbines



Throughout history, Europeans have relied on the sea for sustenance, and once again they are turning to the oceans to harvest energy from the wind. The first to do so was Denmark when, in 1991, it placed 11 turbines off the Atlantic coast near the port of Vindeby. Since then, the concept of offshore wind energy has been gathering momentum, with 17 projects currently providing 600 MW of generating capacity off the shores of northern Europe.

For Europe, this is just the beginning. According to the European Wind Energy Association, another 150 wind projects are being planned, targets that call for an additional 70,000 MW of offshore capacity by the year 2020. In contrast, the United States does not yet have offshore wind farms, but there are some on the drawing boards.

Why the discrepancy between continents? Europeans have long enjoyed greater financial incentives for wind development. For example, Germany offers low-interest loans for wind development. Ireland forgives taxation on a portion of utility company profits reinvested in renewable energy. However, geography plays a major role as well—in much of northern Europe there is a scarcity of land-based wind sites with adequate resource. This is compelling the wind industry in nations such as Denmark, Germany, and Great Britain to move offshore where winds are stronger, steadier, and abundant.

In the United States, where the land-based wind resource in the Midwest is abundant, the incentive to go offshore is not as obvious until one compares the proximity of the major East Coast load centers with the wind resources. Projects located in the ocean can avoid long-distance electric transmission bottle necks and take advantage of the local high winds. The most publicized offshore undertaking in this country has been the Cape Wind project, proposed to stand in waters several miles from Martha's Vineyard, Massachusetts. The prospect of a wind farm has raised objections from some residents who think the turbines could ruin their view. Others back the project, including environmental groups such as Greenpeace and the Union of Concerned Scientists.

In New York, the Long Island Power Authority has proposed another offshore wind farm that could soon add 140 MW to the electric grid—a proposal that thus far appears to meet the approval of some Long Island organizations, the Governor, and several environmental groups.

Ideas that have incubated for years in the labs of NREL's National Wind Technology Center could create technologies to enable wind farms to generate electricity much farther away from the shore—in deep water, where the winds are stronger, windy sites are an order of magnitude more abundant, and land-use conflicts are easier to mitigate. With an aggressive R&D program to push it forward, researchers believe this technology could be economically feasible in 10–15 years.

How deep is deep water? "There is no universal definition," says scientist Walt Musial. "For purposes of discussion, let's say it's the depth where we would need substantial new technology." Currently that depth is 20 or perhaps 30 meters, he says. Beyond that, it is no longer practical to use the monopole construction of today's turbines, in which a steel pole 5 meters or more in diameter is driven into the seabed floor.

Floating platforms of the kind used in offshore oil and natural gas drilling may be replacing the monopole. Variations of this theme are being computer-modeled by NREL's wind scientists, working with researchers from the Massachusetts Institute of Technology (MIT). Using wind turbine codes such as FAST or ADAMS with MIT's floating structures dynamics code, SML, they strive to simulate the inevitable rocking motion of a floating platform with the workings of a wind turbine. By approximating the load environments in which offshore wind turbines operate, their work will foster more reliable turbine design tools, and better techniques for reducing the uncertainty of offshore wind turbines.

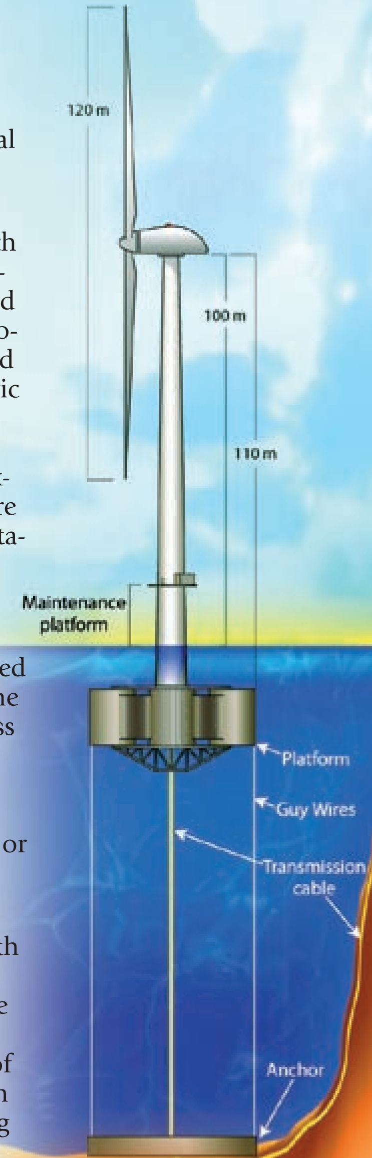
A challenge inherent to farther-out wind farms is transmitting the power to shore. From today's turbines, electricity is transferred via submarine electric cables. Greater distances will add cost, but it won't necessitate any radical new science, Musial believes.

One idea for transferring energy is tied to the vision of a future "hydrogen economy," in which hydrogen would be a major fuel and energy carrier for the nation. At remote wind sites (on land as well as at sea), electricity could be used to produce hydrogen from water. This approach would not only obviate the need for investing in electric cables and infrastructure, it would also provide a high-value dispatchable energy source whose production and use would emit no carbon dioxide. The hydrogen would be transported to shore and used to supply fuel and power for transportation, industry, and other applications.

Aside from technological advances, large-scale deep-water offshore wind development would require new thinking, says Musial. "We've learned a lot about the use of floating platforms from the oil and gas industry, but we couldn't do business the same way. Our intent would be to leapfrog the status quo." For example, wind developers would seek economies of scale by manufacturing platforms by the hundreds, rather than one or two at a time as in the petroleum industry.

New thinking would also evolve from management practices at today's wind installations, both offshore and land-based. Operation and maintenance costs for offshore installations might be triple those of land-based systems. Turbines off the European coasts currently experience a lot of downtime because they are often inaccessible in severe weather. NREL researchers are developing ways to make future turbines more reliable, tolerant of faults, and capable of diagnosing themselves.

The U.S. electric grid carries about 920 GW of capacity. The wind off the coasts of New England theoretically could yield a sizable fraction of that amount—perhaps 100 GW of capacity—said David Garman, DOE's assistant secretary for Energy Efficiency and Renewable Energy. Researchers estimate that this capacity could provide enough electricity to run about 40 million U.S. homes. With so much energy so near, NREL scientists are exploring new ways to exploit that resource, applying ideas that were unimagined a decade ago. "We can't let the projects drive the research," says Musial. "We want to get ahead of what's being done today, so new technology is available when the industry is ready."



Shown above is a concept for anchoring large wind turbines in deep water. On the opposite page, a 3.6-MW General Electric wind turbine stands in shallow water in an area off the coast of Ireland known as the Arklow Bank (opposite page). The first seven turbines in this proposed 200-turbine, 520-MW wind field started producing power in 2003. (Photo courtesy of GE Energy, © 2004, General Electric Company.)

For More Information

Musial, W.; Butterfield, S. (2004). "Future for Offshore Wind Energy in the United States." Preprint. 16 pp.; NREL Report No. CP-500-36-313.

Web site for the European Wind Energy Association, accessed December 30, 2004. http://www.ewea.org/.

"Wind Farms off East Coast Could Yield 100 GW of Energy; DOE Official." *Inside Energy*; August 30, 2004; p. 15.